FeatherSail 2: The Next Generation of Sailcraft

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I. Abstract

FeatherSail 2 is designed to demonstrate sail attitude control and to conduct solar research out of the ecliptic plane. It uses solar radiation pressure (SRP) as its primary means of propulsion and attitude control. Three axis attitude control is achieved by "feathering", or rotating sections of the sail out of the plane. The use of SRP means that FeatherSail's lifetime is not limited by on-board fuel reserves.

FeatherSail consists of four main components:

1. De-tumble stage: an expendable section that enables attitude control prior to the sail's deployment.
2. Central Hub: houses the avionics and provides the structural backbone.
3. Four Pods: each deploys four booms and hoists the sail. The fully deployed sail is 34 x 34 m.
4. Science Boom: supports two magnetometers and four cameras to verify successful deployment and monitor sail integrity.

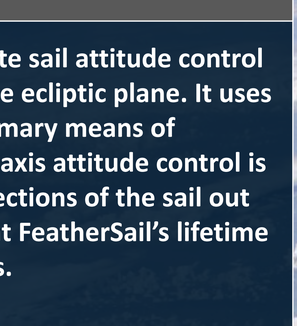
II. Mission Design

Phase 1: Launch and Earth Escape

- Launch Vehicle: Athena II - $26 million
- Eject Date: Oct. 20th, 2016
- Trajectory: C3 = 35 km^2/s^2, i= 28.5 °, Ω = 128 °

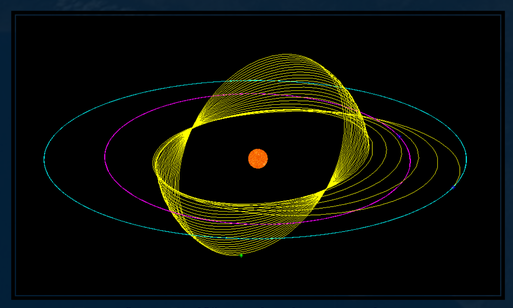
Phase 2: Circularize at 0.5 AU

- Venus Flyby – 100,000 km
- Duration: 2 years, 7 months



Phase 3: Plane change out of Ecliptic

- Final inclination: 60 °
- Duration: 10 years (End of Life)
- Mission: Magnetic field and solar wind data

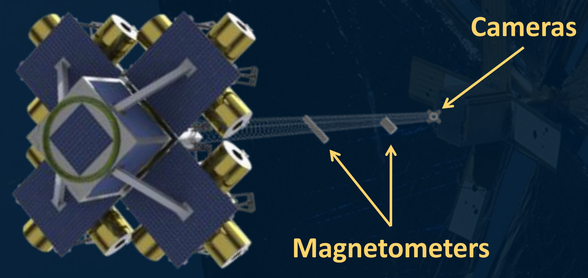


FeatherSail's mission trajectory

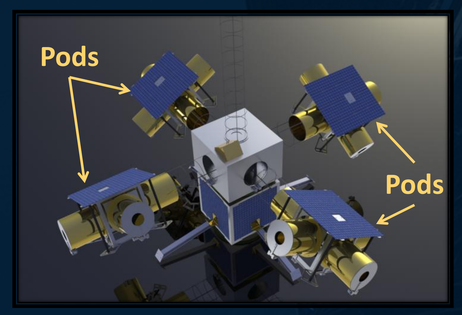
III. Deployment

FeatherSail is launched in its stowed configuration with the pods and de-tumble stage secured to the central hub. It's stowed size is 68 x 68 x 51 in.

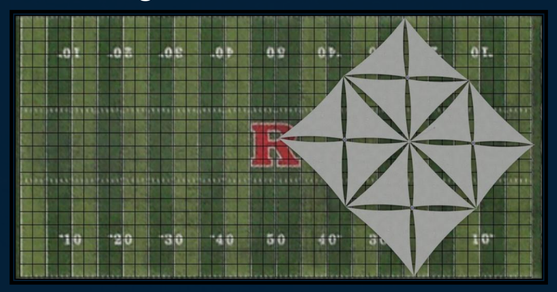
A science boom extends from the main hub normal to the sail plane. It holds two magnetometers and has cameras to verify sail deployment and monitor sail integrity.



The four pods extend from the hub with ATK's 8 inch Coilable booms. They rotate throughout deployment until they are fully extended.

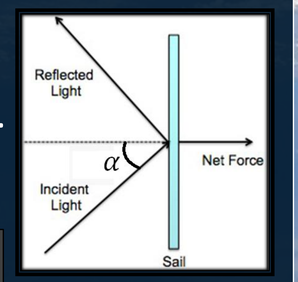


A motor in the pods reels in the halyards, hoisting the sail. The de-tumble stage detaches from the main hub.



IV. Attitude Control

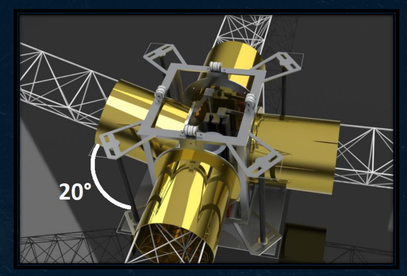
FeatherSail uses SRP for propulsion and attitude control. A steady stream of photons from the sun is reflected, and the momentum is transferred to the sail.



Solar Radiation Pressure Force: Specular Reflection Model

$$\vec{F}_{srp} = 2 \cdot \frac{I}{c \cdot {R_{AU}}^2} \cdot A_{sail} \cdot \cos^2(\alpha) \cdot \hat{n}_{sail}$$

On each pod, two booms can "feather" up to 20°. Unique combinations of sail feathering provides three axis attitude control: roll, pitch and yaw.



Single boom tilted 20°

Roll Maneuver Feathering

V. Avionics

4. Science Boom

- Flux Gate Magnetometer
- Vector Helium Magnetometer
- Camera

3. Pod Components

- Unfurling Motors
- Sun Sensors
- Local Power Regulator
- Power Switch
- Feathering Motors
- Solar Arrays
- SMART

Pod 2

Pod 4

- Power Distribution Board
- Battery Control Regulator
- Star Tracker
- Electrostatic Analyzer
- Flight Computer
- Data Storage
- Multispectral Imager
- Comm
- Battery

1. De-Tumble

- Reaction Wheels
- Solar Arrays
- Battery
- Camera
- Controller
- IMU
- Comm

2. Main Hub

Pod 3